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SOPITE SYNDROME
IN OPERATIONAL
FLIGHT TRAINING

by

David E. Flaherty

September 1998

Thesis Advisor:	John K. Schmidt
Co-Advisor:	Robert R. Read
Second Reader:	Samuel E. Buttrey

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The questionnaire data was coded/tabulated for entry on a spreadsheet for subsequent analysis. Descriptive and non-parametric statistical techniques were used to analyze the data set obtained. The results show sufficient evidence between the levels of symptomology and their relationships when comparing conditions that support the existence of Sopite Syndrome in operational flight training.

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SOPITE SYNDROME IN OPERATIONAL FLIGHT TRAINING

David E. Flaherty
Lieutenant Commander, United States Naval Reserve
B.S., Massachusetts Maritime Academy, 1985

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Author: ____________________
David E. Flaherty

Approved by: ____________________
John K. Schmidt, Thesis Advisor

____
Robert R. Read, Co-Advisor

____
Samuel E. Buttrey, Second Reader

____
Richard E. Rosenthal, Chairman
Department of Operations Research

ABSTRACT

Sopite Syndrome is a poorly understood response to motion characterized by drowsiness, fatigue, sleep disturbances, and mood changes. It is distinct from "regular" motion sickness or common fatigue, and may affect the performance of motor vehicle as well as aircraft operators. The potential impact Sopite Syndrome may have on military aviation is relatively unknown. Recently, research in situations relevant to aviation training and flight operations has been initiated. The present study is part of that effort. Its goal is to determine the incidence, severity, and association of Sopite Syndrome characteristics in a population of Student Naval Flight Officers (SNFOs). Seventy-eight SNFOs assigned to Training Squadrons Four and Ten located at the Naval Air Station Pensacola, Florida completed a questionnaire designed to capture evidence/incidence of fatigue, motion sickness, drowsiness, and sleep disturbances during days when SNFOs flew versus non-flying days.

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EXECUTIVE SUMMARY

The training of student aviators (SAs), both Naval Pilots and Naval Flight Officers (NFOs), is one of the most expensive investments undertaken by the Department of the Navy each year (Riebel, 1996). In a period of downsizing and budgetary constraints it is imperative to reduce attrition rates in SAs. Motion sickness experienced by SAs in their initial phases of flight training might be responsible for a significant proportion of student attrition (Hutchins & Kennedy, 1965; Naval Operational Medical Institute (NOMI), 1997). In fact, the incidence of motion sickness among SAs varies between 11 and 38 percent dependent upon aircraft type and the stage of training (NOMI, 1997). In respect to SAs, motion sickness is understood to imply nausea to the point of incapacitation, vomiting, degraded flight performance or early termination of flight.

Numerous studies have been conducted concerning motion sickness susceptibility of SAs in military aircraft (Hutchinson & Kennedy, 1965; Royal & Jessen, 1984). These studies did not take into account a poorly understood response to motion known as Sopite Syndrome. Sopite Syndrome is a form of motion sickness characterized by drowsiness, fatigue, sleep disturbances, and mood changes (Graybiel & Knepton, 1976). It is distinct from "regular" motion sickness or common fatigue. Besides drowsiness, none of the primary symptoms of "regular" motion sickness are considered part of the diagnostic criteria of Sopite Syndrome (Lawson & Mead, 1997). Therefore, the syndrome may have as great an impact on flight performance and safety as the widely recognized symptoms of "regular" motion sickness (Lawson & Mead, 1997).

Recently, research in situations relevant to aviation training and flight operations has been initiated. The present study is part of that effort. Its goal is to determine the incidence, severity, and association of Sopite Syndrome characteristics in a population of Student Naval Flight Officers (SNFOs). Seventy-eight SNFOs assigned to Training Squadrons Four and Ten located at the Naval Air Station in Pensacola, Florida completed a questionnaire to capture evidence/incidence of motion sickness, drowsiness, fatigue, and sleep disturbances during days when SNFOs flew versus non-flying days. The questionnaire data was coded/tabulated for entry on a spreadsheet for subsequent analysis. Descriptive and non-parametric statistical techniques were used to analyze the data set obtained. Specifically, Sopite Syndrome characteristics as they vary across conditions were evaluated. Additionally, cluster analysis was performed to classify subjects into low- and high-risk groups.

Through the use of Wilcoxon Signed Rank test the size of increase between the conditions for each respective characteristic was determined to be significant in the case of motion sickness and fatigue ($p < 0.05$). In analyzing relationships, Spearman rho correlations were computed for each respective pair of characteristics. Drowsiness/sleep was the only pair of characteristics not significant ($p > 0.0083$) under the null hypothesis that the correlation between each respective pair of characteristics is zero. An important finding from the research is that an increase in motion sickness was highly correlated with increases in drowsiness, fatigue, and sleep.

Since the presence of Sopite Syndrome can not be definitively shown, a symptomatic profile was drafted per symptomology delineated in the literature to determine low- and high-risk group membership. The choice of candidates for Sopite

Syndrome was validated using a data permutation test. The permutation test differs from "bootstrapping" in that it employs large number of repetitive computations without replacement to estimate a population characteristic. In summary, the permutation test showed that a significant difference existed between the Sopite Syndrome candidates and the remaining population ($p < 0.05$).

In following, a Wilcoxon-Mann-Whitney test of significance was conducted on the Sopite and Non-Sopite groups. Under the null hypothesis that the two groups are from the same distribution, the size of increase was significant for motion sickness, drowsiness, and sleep ($p < 0.0125$). The decision was to reject the null hypothesis and conclude that the two groups are not from the same distribution.

Finally, cluster analysis was used to classify subjects into low- and high-risk groups. The technique is designed to perceive groups (clusters) in data, in such a manner that subjects belonging to the same group look like one another, while subjects in different groups look different. The actual symptomatic profile selection groups were compared using the output from three different cluster analysis algorithms. The overall classification error rates for the various algorithms ranged from 19.2% to 23.1%.

This thesis provides a snapshot of Sopite Syndrome in operational flight training. The design of the questionnaire was not intended to establish specific interpretations of symptomology, but to determine if Sopite Syndrome existed in a sample population of SNFOs in operational flight training. In fact, sufficient evidence was presented. Therefore, the techniques performed are deemed successful in supporting the existence of Sopite Syndrome in operational flight training.

I. INTRODUCTION

A. BACKGROUND

The training of student aviators (SAs), both Naval Pilots and Naval Flight Officers (NFOs) is one of the most expensive investments undertaken by the Department of the Navy each year (Riebel, 1996). In a period of downsizing and budgetary constraints it is imperative to reduce attrition rates in SAs. Motion sickness experienced by SAs in their initial phases of flight training might be responsible for a significant proportion of student attrition (Hutchins & Kennedy, 1965; Naval Operational Medical Institute (NOMI), 1997). In fact, the incidence of motion sickness among SAs varies between 11 and 38 percent dependent upon aircraft type and the stage of training (NOMI, 1997). Therefore, SA attrition due to motion sickness holds significant interest for the Chief, Naval Air Training Activity (CNATRA) and the Navy Aeromedical community.

Established in 1939, the Naval Aerospace Medical Research Laboratory (NAMRL) conducts research and development in aviation medicine and allied sciences to enhance the health, safety and readiness of Naval aviation personnel (NOMI, 1997). As part of fulfilling its mission, numerous studies were conducted to predict the susceptibility of individuals to motion sickness (Royal, Jessen, & Wilkens, 1984). Generally, they consisted of rotation room studies, motion sickness questionnaires, and rotation with head movement trials. However, these studies did not selectively screen for Sopite Syndrome, a poorly understood response to motion characterized primarily by drowsiness, fatigue, sleep disturbances, and mood changes (Lawson & Mead, 1997).

Graybiel and Knepton (1976) first identified Sopite Syndrome in research conducted with NAMRL's Slow Rotation Room. They found drowsiness frequently occurred even after adaptation to motion sickness symptoms had subsided. Earlier research tends to support their findings and the potential existence of this phenomenon (Graybiel, Clark, & Zarriello, 1960; Graybiel, Kennedy, Knoblock, Guedry, Mertz, McLeod, Colehour, Miller, & Fregley, 1965). Eventually enough evidence was accumulated in both clinical and scientific research to support the notion that Sopite Syndrome and its collection of symptoms was distinct from "regular" motion sickness (Lawson & Mead, 1997).

It is contended that one of the important indications in diagnosing motion sickness is drowsiness (Lawson & Mead, 1997). In addition, other significant symptoms include vomiting, nausea, skin color changes, cold sweats, and increased salvation (Miller & Graybiel, 1974). These are distinctly different from those indicative of Sopite Syndrome and sets the latter apart as a unique phenomenon. Besides the dissimilarity in symptoms, Sopite Syndrome also follows a separate time course (Lawson & Mead, 1997). Sopite Syndrome symptoms can persist long after nausea has subsided (Graybiel & Knepton, 1976). Further, it often appears before the onset of nausea. Related symptoms considered part of Sopite Syndrome diagnostic criteria are apathy, lethargy, desire to be left alone, inability to concentrate, frequent day napping, irritability, melancholy, and performance errors (Lawson & Mead, 1997). Additionally, it can even totally debilitate certain individuals. Given that Sopite Syndrome is distinct from "regular" motion sickness, it is a potential concern in various forms of transportation and may be

particularly hazardous in military aviation where other challenges are already present (Lawson & Mead, 1997).

Lawson (personal communication, May 29, 1998) indicates that the United States Air Force (USAF) and the National Aeronautics and Space Administration (NASA) know little about Sopite Syndrome. Since the original work of Graybiel and his colleagues in 1976, the only NASA-supported work in the area of Sopite Syndrome has consisted of a few pilot experiments. In these experiments subject moods were tracked following parabolic flight. Recent briefs by NAMRL at the 12th Annual Man in Space Symposium, held in Washington, D.C. (1997) and the Aerospace Medicine Association Conference held in Seattle, Washington (1998) comprise the bulk of USAF and NASA knowledge on this topic. Currently, NAMRL has the only active research program addressing Sopite Syndrome.

The existence of Sopite Syndrome may significantly affect the performance and safety of military personnel in motion-based environments (Lawson & Mead, 1997). As part of its ongoing research effort, NAMRL researchers designed a questionnaire to capture evidence of SA's experience of Sopite Syndrome symptoms in training. The questionnaire was administered to two separate training squadrons at the Naval Air Station in Pensacola, Florida. The objective was to assess if Sopite Syndrome was present among SAs undergoing operational flight training.

B. PURPOSE

The purpose of this thesis is to analyze responses to a questionnaire and determine if evidence of Sopite Syndrome exists in operational flight training. The objective is to

analyze the frequency of Sopite Syndrome characteristics and to correlate them in a population of SAs in an operational setting.

C. PROBLEM STATEMENT

The training of SAs is one of the most expensive investments undertaken by the Department of the Navy each year. In a period of downsizing and budgetary constraints it is imperative to reduce attrition rates among SAs. Medical pre-screening and selection programs must be extremely meticulous and thorough to reduce these high attrition rates as SAs enter and progress through the aviation-training pipeline. Additionally, the loss of over one and a half years of training by those who are attrited is extremely unmotivating to those individuals. This loss can hurt their career and promotional status in years to come. Furthermore, anything that has potential of causing a mishap to aircraft and personnel needs to be explored.

Due to the potential implications of Sopite Syndrome on SA operational flight training performance and safety, a thorough investigation of the symptoms captured via the questionnaire must be undertaken. This study investigated the following research questions:

1. Determine the measures of central tendency and dispersion of symptoms indicative of Sopite Syndrome (i.e. Drowsiness, Fatigue, and Sleep) reported.

2. Do correlations exist between the symptoms of Motion Sickness during Flight Training, Drowsiness, Fatigue, and Sleep? For example: Does correlation exist between the rates of increase in motion sickness and drowsiness during flight? If so, is this correlation significant?

3. Since the presence of Sopite Syndrome cannot be definitely shown, can a symptomatic profile of Sopite Syndrome be developed to divide individuals into low- and high-risk groups?

4. Conduct a comparison of the actual symptomatic profile selection groups under various cluster analysis algorithms for individual assignment into low- and high-risk groups.

5. Are sleep disturbances prevalent in SAs, and if so, what portion is affected? Which questions explain this difference and identify SAs as Sopite Syndrome candidates?

6. Is there an increase in the amount of fatigue, distinct from common fatigue, that is reported by SAs, and if so, which questions explain this difference and which would be evidence that Sopite Syndrome exists?

D. BENEFITS

The Naval Research Medical Research Laboratory (1996) states that the objectives of information learned from this research and future scheduled studies are to:

1. Provide fleet recommendations and training examples to address improvements in safety and performance.

2. Modify selection and screening processes of new accessions into designated programs in order to reduce attrition and associated costs.

3. Design a symptom checklist for Sopite Syndrome, which will improve understanding and increase the knowledge base of both military and civilian personnel in all facets of transportation.

E. SCOPE AND LIMITATIONS

The research in this study is limited to the 78 questionnaires that were administered to Training Squadrons Four and Ten assigned to Naval Air Station, Pensacola. Due to the mission of these training squadrons, only student NFOs (SNFOs) were administered the questionnaire. The sample frame did not include student Naval Pilots. It is noted that the severity of symptomology experienced in student Naval Pilots while flying may be different than that of SNFOs due to differences in visual reference and cognitive workload.

Additionally, the questionnaire was designed by NAMRL researchers and administered prior to the author's experience tour. A potential disadvantage of self-administered questionnaires is the design of the questions. Questions must be written carefully to collect information about objectively verifiable facts and events (Fink, 1995). Poorly designed questions may not meet question objectives resulting in flawed data. NAMRL researchers were sensitive to this issue and screened question content and design carefully.

II. LITERATURE REVIEW

A. OVERVIEW

Literature consulted in the research process consisted of NAMRL files and library assets, MEDLINE internet on-line services, motion sickness publications and journals, and Aero Space/Aviation, Space, and Environmental Medicine archives. Topics covered motion sickness' history, symptoms, preventive medications, and effect on military operations. Furthermore, research looked into Sopite Syndrome's origins, its distinction and differences from "regular" motion sickness, and potential impact on military aviation.

B. MOTION SICKNESS

Motion sickness is not limited to the 20th century; in fact, it was the ancient Greeks who first reported the ailment (Raber, 1990). The word "nausea" derives from the Greek "naus" which means a "ship" (Woolf, 1981). In these earlier times, individuals were considered weak and lacking in "moral fiber" if they manifested motion sickness symptoms (Collins & Lentz, 1977). Literature through the late 1940s supported this viewpoint despite chronic motion sickness in individuals renowned for their courage, such as Julius Caesar and Lawrence of Arabia (Collins & Lentz, 1977). Other notable military figures were victimized by motion sickness, such as Cicero and Admiral Lord Nelson (Raber, 1990). It is claimed that Cicero stated he would rather die than once more suffer the agony of nausea maris (motion sickness). Even on his final voyage, to the battle of Trafalgar, Admiral Lord Nelson suffered from an encounter with motion sickness.

The prevention of motion sickness in the military has been the focus of numerous studies (Hutchins & Kennedy, 1965; Levy, Jones & Carlson, 1981; Giles & Lochridge, 1985). Motion sickness became a problem of considerable military significance with the emergent need to transport very large numbers of troops by land, air, and sea, at the onset of World War II (Reason & Brand, 1975; Collins & Lentz, 1977). In peacetime, motion sickness for the most part is a disagreeable and annoying condition that places no extreme threat on military life; however, in wartime the situation changes. Military doctrine exhibited in recent conflicts required the swift transport of military personnel by land, air, and sea to all areas of the globe. Upon completion of such a logistical movement in military operations, military personnel experience motion sickness that affects their combat efficiency and personal safety at a time when their services are most urgently needed and they are most vulnerable (Dehart, 1985). Therefore, the potential impact of even mild motion sickness constitutes a major hazard to the success of the mission and to the lives of those involved (Strongin & Charlton, 1991; Raber, 1990).

Motion sickness is a state of less than perfect health characterized by specific symptoms induced in response to unaccustomed conditions existing in one's motional environment (Dehart, 1985). Very nearly all methods for rating symptoms and determining motion sickness severity rely on subjective observation and self-report (DiZio & Lackner, 1992). The usual progression of motion sickness symptoms is first lethargy which is followed by apathy, stomach awareness, nausea, pallor, cold sweating and increased salvation, followed by retching and vomiting (Graybiel, Wood, Miller, & Cramer, 1968; Dehart 1985). These symptoms appear in different combinations with

varying severity depending on the individual and exposure conditions (DiZio & Lackner, 1992).

Physiological correlates of motion sickness consist of changes in the human body's cardiovascular, respiratory, gastrointestinal, and biochemical systems (Reason, 1975). In general, evidence regarding the cardiovascular events that are associated with the onset of motion sickness indicates they are of little diagnostic value, being unreliable and inconsistent. For example, even though motion sickness may frequently be accompanied by an increase in respiratory rate, this is by no means the rule in general. Reason (1975) states that gastrointestinal changes that are associated with motion sickness consist of a reduction in gastric movement and relaxation of the visceral involuntary muscles. Finally, a few of the biochemical changes due to motion sickness consist of ketosis (i.e. an abnormal increase of ketone in the body), varying glucose utilization, and increases in blood enzyme concentrations.

Numerous studies have been conducted concerning motion sickness susceptibility of aircrews in military aircraft. In particular, airsickness among student aviators was found to be quite common (Hutchins & Kennedy, 1965; Royal & Jessen, 1984). Flight in turbulent air with continuous sudden and unanticipated changes in direction with slight reference to spatial orientation is good reason to feel sick. It follows that airsickness is considered among the most annoying forms of motion sickness (Strongin & Charlton, 1991). Technological improvements in modern combat aircraft have significantly increased the probability that military aircrew will be exposed to these conditions for extended periods. In respect to SAs, airsickness is understood to imply nausea to the

point of incapacitation, vomiting, degraded flight performance, or early termination of flight (NOMI, 1997).

Identification of SAs susceptible to motion sickness could be of significant benefit in both monetary and human terms. Kennedy (1975) showed that a motion sickness questionnaire could be useful in predicting susceptibility to motion sickness or the likelihood of flight training success in SAs. The questionnaire looked into each subject's exposure to motion and moving devices, their assessment to susceptibility, and symptoms experienced in these devices (Kennedy, 1975). Subjects were then exposed to a Dial Test aboard the Pensacola slow rotation room, and it was determined that the questionnaire and Dial Test scores correlated. However, in addition to airsickness (motion sickness) SAs may be affected by Sopite Syndrome, which was not measured or taken into account in the Kennedy (1975) study. Sopite Syndrome may have as great an impact on flight performance and safety as the widely recognized symptoms of "regular" motion sickness (Lawson & Mead, 1997).

C. SOPITE SYNDROME

Sopite Syndrome is a form of motion sickness characterized by drowsiness, fatigue, sleep disturbances, and mood changes (Graybiel & Knepton, 1976). Besides drowsiness, none of the primary symptoms of "regular" motion sickness are considered part of the diagnostic criteria of Sopite Syndrome (Lawson & Mead, 1997). Research of motion sickness has shown that at times an individual may be afflicted exclusively by the symptoms of Sopite Syndrome (Graybiel & Knepton, 1976; Askins, Mead, Lawson, & Bratley, 1997; Bratley, Lawson, & Mead, 1997). These symptoms often go unrecognized,

since they are not part of the symptomology associated with "regular" motion sickness. To this degree, Sopite Syndrome is not correctly associated with the motion that incites its arousal (Lawson & Mead, 1997).

Generally, the symptoms characteristic of Sopite Syndrome are merged together with symptoms associated with "regular" motion sickness. However, there exist two specific circumstances in which Sopite Syndrome alone accounts for symptoms. (Graybiel & Kneapton, 1976). One case is when the magnitude of the eliciting stimuli is at or approaching an individual's susceptibility; at this point the syndrome is evoked in the absence of other motion sickness symptoms (Lawson & Mead, 1997). Therefore, Sopite Syndrome can be present in the absence of more apparent symptoms of motion sickness such as nausea and vomiting (Graybiel et al., 1968; Miller & Graybiel, 1974). The second case takes place during the course of prolonged exposure in a motion environment when an individual adapts to the environment, which results in the sudden or gradual disappearance of motion sickness symptoms, except for reactions characteristic of Sopite Syndrome (Lawson & Mead, 1997). Therefore, Lawson and Mead (1997) state that sometimes the sole manifestation of motion sickness is the symptoms of Sopite Syndrome. Such cases have been classified as "pure" Sopite Syndrome.

Sopite Syndrome can last long after nausea and vomiting have subsided and can be debilitating to some individuals (Graybiel & Knepton, 1976). This was seen in 1965, when four aviators were exposed to a rotating environment for a period of twelve days (Graybiel et al., 1965). Lawson and Mead (1997) explain that to promote friendly competition the subjects were two Navy and two Marine Corps officers who had

completed the acrobatic stage of flight training. Additional selection factors were good general fitness and mental discipline and a history of less than average susceptibility to motion sickness. Each officer was highly motivated and was explained the importance of the experiment on the space effort. However, even after adapting to nauseating stimuli each showed signs of Sopite Syndrome including an episode in which one officer fell asleep on watch (Graybiel et al., 1965).

Therefore, besides the difference in symptoms, Sopite Syndrome appears to occur at different periods in time in respect to the development and persistence of motion sickness. It was Graybiel and Knepton, in 1976, who determined that the time course of Sopite Syndrome differs somewhat from that of the general symptomology of "regular" motion sickness.

One distinct observation made on human subjects living in a slow rotation room for two day periods is how rapidly subjects transitioned from a high state of readiness to states of fatigue and sleep (Graybiel et al., 1960). While spinning at 5.44 revolutions per minute, one subject was observed to become extremely sleepy and slept two and one-half hours the first morning and part of the afternoon. A second subject experienced apathy and sleepiness the afternoon of the first and second days. Each subject reported a normal night's sleep prior to conducting the experiment. Similar results were concluded during the exposure of the four aviators participating in the twelve-day study, in which subjects would rapidly go from fully alert or excited states to heavy sleep (Graybiel et al., 1965). Subjects yawned frequently and complained of intense fatigue and drowsiness throughout

the 12 days of rotation. These events occurred despite frequent naps and occasionally sleeping longer than usual at night (Graybiel et al., 1965).

It is noted that prolonged exposure in a rotating environment is an uncommon experience and differs in important respects from conditions an individual would feel in high seas or dynamic flight (Lawson & Mead, 1997). One noticeable difference is in the fact that in the rotating environment the subject's movements are required to generate the unusual accelerations where as at sea or in the air, fixation of the head and body may relieve the effects but would not do away with the unusual external forces to which the individual is subjected (Graybiel et al., 1965). Hence, when an individual is seated with head fixed or sleeping while rotating in a slow rotation room the conditions is not that different from if the room was in fact stationary. Movements that result in functional interference for most part fall into two categories: whole body movements and rotation of the head out of the plane of rotation of the room. Stability is another important difference when comparing ship or aircraft with a slow rotation room; individuals regarded the room as not only being level and having upright walls, but also as stable.

Living in a slow rotation room involves a degree of isolation, confinement, and boredom (Lawson & Mead, 1997). Therefore, a primary concern of the researchers who conducted the twelve-day slow rotation room study was to sufficiently motivate and stimulate the four aviator subjects (Graybiel et al., 1965). Lawson and Mead (1997) state that in spite of crowded conditions in the 20-foot diameter room, there was ample room to provide comfortable bunking, exercise, and recreation (including television). Furthermore, meticulous attention was given to the niceties of life, including individual

preparation of meals to suit desired tastes. Nevertheless, subject symptoms exhibited strong evidence of Sopite Syndrome.

It is feasible that Sopite Syndrome acts upon other medical ailments. As early as 1944, it was suggested in a report by the National Research Council Committee on Selection and Training of Aircraft Pilots "that [without satisfactory supporting evidence] much motion sickness is of a severity so low that it comes to the attention neither of the victim, nor of his associates; being characterized only by emotional depression and loss of interest in work (Wendt, 1944)." Therefore, Lawson and Mead (1997) state there may exist the likelihood for Sopite Syndrome to exacerbate the symptoms of depression or lethargy.

For example in a case of chronic depression, a 27 year old designated aviator described his mood as "depressed" and reported his last feelings of happiness approximately two years earlier (Moore & McDonald, 1993). He lacked motivation and appeared to have trouble concentrating and complained of episodes of "blank stares" and inattention to detail. Furthermore, he reported frequent early morning awakenings and admitted to withdrawing from others, including his wife and avoiding social contact whenever possible. The onset of depression coincided with the individual entering the field of aviation as a profession in the United States Navy. Therefore, there exists the potential that Sopite Syndrome may have interacted with or confused the diagnosis of chronic depression.

A number of features of the Sopite Syndrome make it worthy of increased attention. Just as unrecognized disorientation or hypoxia (i.e. the deficiency of oxygen

reaching the tissues of the body) can pose a gradual and cumulative hazard to operators of moving vehicles, unrecognized characteristics of Sopite Syndrome such as lapses in attention could threaten mission objectives and safety of military personnel (Lawson & Mead, 1997). Particularly hazardous in the transportation setting, Sopite Syndrome may occur during and after flight, onboard ships at sea, in micro-gravity, and also during and after simulator and virtual environment use (Lawson & Mead, 1997).

Sopite Syndrome is almost always present in airsickness; likewise it is found in other types of motion sickness such as sea and space sickness (Graybiel & Kneapton, 1976). The syndrome is most often observed during extended exposure conditions (Graybiel & Kneapton 1976); however, current research indicates that a small number of student aviators will describe symptoms suggestive of the syndrome even when exposed to a short fifteen-minute stimulus (Lawson & Mead, 1997). Furthermore, this brief stimulus is considered an exciting experience by most SA trainees (Askins et al., 1997; Brately et al., 1997). Throughout the duration of the training session, subjects actively participate in different kinds of tasks while listening to music from the movie "Top Gun" accompanied by an invigorating taped commentary describing various spatial disorientation illusions (Lawson & Mead, 1997).

Evidence implies that in certain situations the existence of Sopite Syndrome is a potential hazard. The key components of drowsiness, fatigue, sleep disturbances, and mood shifts are of particular concern, since a short lapse in attention can be deadly to operators of vehicles in various modes of transportation (Lawson & Mead, 1997), specifically, civilian and military aviation where little is known of the effects of Sopite

Syndrome on performance and its potential impact. These factors may have profound implications on personnel safety and mission objectives (Lawson & Mead, 1997). Furthermore, there is factual support of documented performance deficits caused by unusual motion; a methodical plan is needed to determine to what extent such deficits are attributed to the Sopite Syndrome.

D. TREATMENT ASSESSMENT

Reason and Brandt (1975) indicated that motion sickness literature is plentiful with recommendations for preventing motion sickness and for alleviating its symptoms. In earlier times, practically anything that could be carried, worn or swallowed was prescribed at one time or another. Included in such prescriptions were opium, cocaine, quinine, nitrous oxide, warm salt water, strong tea, coffee, and various forms of alcohol. Additionally, there existed a number of conflicting regimens. For example, some writers recommended traveling on full stomachs while others preached fasting prior to departure. When all else failed the unfortunate traveler was advised to resort to prayer.

Numerous and diverse types of medications have been studied in evaluating the prevention of motion sickness. Certain drugs are undeniably effective against motion sickness in that sufficient protection was demonstrated satisfactorily in wide variety of exasperating situations. The medication of choice for SAs diagnosed with air sickness is phenergan 25mg with ephedrine 25mg taken 60 minutes prior to flight (NOMI, 1997). Other medications known as scopolamine, meclizine, and dramamine are not currently recommended by the Navy (NOMI, 1997).

As stated earlier, symptoms of Sopite Syndrome such as drowsiness and fatigue can persist long after nausea and vomiting have subsided. Such symptoms can disrupt an individual's performance, identifying the need for medication to counteract these effects. A study of therapeutic effects of proven anti-motion sickness drugs on nausea and vomiting demonstrated inconsistent results in respect to Sopite Syndrome (Wood, Stewart, Wood, Manno, Manno, & Mims, 1990). This provides further evidence that the existence of Sopite Syndrome is a distinct entity than that of motion sickness (Lawson & Mead, 1997).

E. SURVEY METHODOLOGY

Many diverse questionnaires have been utilized in the past to determine an individual's personal history of motion sickness (Hutchins & Kennedy, 1965; Kennedy, 1975; Royal, Jessen, & Wilkens, 1984; Geeze & Pierson, 1986; Strongin & Charlton, 1991). In most cases the basic components are quite similar; each subject is asked to indicate the various forms of motion or transportation that have made them sick (if any), and what their frequency and severity of symptoms are (Reason & Brand, 1975). Analysis of the data is then used to classify an individual as to susceptibility.

Reason and Brand (1975) state that the principal advantage of using a questionnaire is that unlike the "actual exposure" techniques, one can sample an individual's sickness experience over a wide range of eliciting conditions. Additionally, questionnaires are relatively fast and easy to administer and record. Furthermore, notable experiences with motion sickness are not difficult for a subject to recall, nor do they object to commenting on motion sickness since it tends not to be a sensitive issue. Above

all, research has established that motion sickness questionnaires are reliable and valid tools (Hutchins & Kennedy, 1965; Kennedy, 1975; Geeze & Pierson, 1986; Strongin & Charlton, 1991).

However, there are some potential disadvantages with administering questionnaires. If an individual feels that his or her answers may influence his or her career, the responses may not always be absolutely truthful in order to avoid retribution (Reason & Brand, 1975). One might think that aviation students in flight training would downplay their histories of motion sickness and severity of symptoms for such a reason. Nevertheless, Reason and Brand (1975) indicate that aviation students tend to tell the truth in motion sickness questionnaires.

Another potential problem is that unlike an interviewer-administrated questionnaire there is no individual present during a self-administered questionnaire to exercise quality control with respect to answering all questions, meeting question objectives, or the quality of answers provided (Fink, 1995). Furthermore, questionnaires in most cases are incapable of resolving fine differences in motion sickness susceptibility. At best, separations can be made out between slight and moderate susceptibility, and the moderately susceptible from those with extreme susceptibility (Reason & Brand, 1975). Reason and Brand (1975) state that any finer degree in decision is beyond the ability of a questionnaire.

F. SUMMARY

In reviewing the literature presented in this chapter, little information can be derived through the readings to provide insight into the research questions stated. Since

Sopite Syndrome research is in its early stages the specific criteria and associated physiological factors concerning its existence are undetermined at this time. Consequently techniques for determining its composition and further assignment into low- and high-risk groups are unavailable. However, the slow rotation room studies by Graybiel and his colleagues in the 1960's, along with standard motion sickness symptomology defined in research, furnished insight needed to summarize the less complex questions concerning descriptive statistics and symptom relationships.

It is clear that there is a distinct difference in symptomology between "regular" motion sickness and Sopite Syndrome. Additionally, it is known that the time course of symptoms characteristic of Sopite Syndrome vary from that of "regular" motion sickness. Moreover, Sopite Syndrome is long-lasting; research has shown specific cases that have lasted hours to days. Finally, Sopite Syndrome may occur during and after flight and onboard ships at sea. Therefore, the existence of Sopite Syndrome may significantly affect the performance and safety of military personnel.

III. DATA AND METHODOLOGY

A. RESEARCH APPROACH

This research involved analysis of the squadron questionnaire in order to determine the rate of occurrence, character, and severity of Sopite Syndrome symptoms before and after missions. Only four of the eight scales which comprise the questionnaire were used in the statistical analysis (i.e. Motion Sickness during Flight Training, Drowsiness, Fatigue, and Sleep). The scales of Drowsiness, Fatigue, and Sleep represent symptoms characteristic of Sopite Syndrome. Motion Sickness during Flight Training scale was chosen to test for relationships between "regular" motion sickness and Sopite Syndrome symptomology. The remaining scales were used to provide additional insight into the sample population.

Dependent measures included predisposing factors measured by personnel history and motion sickness scales, and the rate of occurrence and magnitude of Sopite Syndrome symptoms measured via the symptom scales (NAMRL, 1996). Two classes of symptoms were measured and compared: those related directly to "regular" motion sickness (i.e., nausea, vomiting, etc.) and those related primarily to Sopite Syndrome. Measurements of Sopite Syndrome were comprised of subjective statements reflective of symptoms related to the syndrome. Explanatory variables included the operational environment (air), the stage of training, and type of missions/training flights (NAMRL, 1996).

B. DATA COLLECTION

1. Subjects

SNFOs assigned to primary flight training at Training Squadron FOUR (VT-4) and Training Squadron TEN (VT-10), whose mission is to provide quality flight training for SNFOs while enabling the personal and professional development of all assigned personnel. There were six female and 72 male SNFO's who participated in the study and were administered a questionnaire to address airsickness and lowered arousal during days when they flew in a T-34C single engine turbo-prop. The average age was 25 years (standard deviation 2.06 years), with a range of 22-33 years. All subjects were asked to participate anonymously in the study regarding their flight experiences.

2. Instrument

The questionnaire was comprised of eight separate scales: Background and Habits, Motion Sickness during Flight Training, Drowsiness during Flight Training, Motion Sickness during Flight, Fatigue, Sleep, Motion Experience, and Social Readjustment. The scales are defined as follows:

(1) The Background and Habits scale investigated for information regarding the individual's gender and age. Additionally, the scale requested each participant to remark on their normal consumption of alcohol, nicotine, caffeine, prescription drugs, and non-prescription drugs during a typical week in flight training. Each participant was then asked to compare these amounts with their ordinary or customary amount of usage.

(2) The Motion Sickness during Flight Training scale consisted of two parts: (a) an introductory explanation of symptoms indicative of "regular" motion sickness, and

(b) an estimate of the quantity of motion sickness a participant typically experienced when he or she felt their worst during their more challenging days of training with the flight program, and the amount he or she experienced during their activities of everyday life. These estimates were rated on visual analog scales ranging from zero (none) to 100 (extreme).

(3) The Drowsiness during Flight Training scale consisted of two parts: (a) an introductory explanation of the most noticeable symptoms of Sopite Syndrome including examples of sleepiness–related effects which comprise the Sopite Syndrome, and (b) two visual analog scales in which the participants were requested to estimate the amount of sleepiness and lowered arousal levels they typically experienced. The levels were to be measured when the participant felt his or her worst during their more challenging days of training with the flight program, and the typical amount each experience during everyday life. The scales ranged from zero (feeling wide awake and alert) to 100 (extreme drowsiness and being unable to stay awake).

(4) The Motion Sickness during Flight scale consisted of two motion sickness symptom checklists in which the participants were given a list of various symptoms for which they were to note the severity of each symptom experienced during the more challenging days of training with the flight program and on a typical day in "normal" life. The responses were evaluated utilizing a 4-point frequency scale: 0 = none, 1 = minimal, 2 = minor, and 3 = major. Furthermore, yes or no responses were requested concerning the physical existence of stomach awareness or discomfort, and retching or vomiting in the participant's condition during the two time periods.

(5) The Fatigue scale requested respondents to answer some questions regarding fatigue, both for their experiences during flight (at their worst during a challenging training day) and in general (everyday life outside the training environment).

(6) The Sleep scale requested respondents to note which statements regarding sleep were true, both during flight training (at their worst during a difficult training day) and in general (everyday life outside of training).

(7) The Motion Experience scale consisted of a list of various motions; the respondent was requested to note the number of times he or she had experienced each of them since the age of 12. The number of experiences was broken down into five frequency categories: none; 1-10; 10-20; 20-30; and greater than 30. Likewise, the respondent was requested to describe how often he or she vomited, felt nausea, or felt drowsy during or after each motion. The respective frequencies were measured in five categories: "never" = < 5% of the time; "rarely" = 5-34% of the time; "seldom" = 35-64% of the time; "frequently" = 65-95% of the time; and "always" = > 95% of the time. Additionally, a section was provided which requested the number of flight hours flown in civilian and military aircraft by the participant. Hours flown in military aircraft were further segregated by aircraft type such as propellers, jets, and helicopters.

(8) The Social Readjustment scale measured the positive or negative life changes that a participant may have been adapting to just before or during flight training. Participants were requested to identify (circle statement number) all statements that applied during flight training or within six months prior to starting the program.

3. Procedure

The principle investigator and research associate made a brief introduction of the questionnaire after Foreign Object Damage (FOD) walk-down for squadrons VT-4 and VT-10. Interested individuals were asked to report to their respective ready rooms for further information. The SNFOs were briefed on the apparent existence of Sopite Syndrome, and its potential effects in the field of transportation, specifically military aviation. Furthermore, the researchers told the participants that the questionnaire was approved by their Commanding Officers and that any data received would be anonymous and could not be used to identify a respondent.

The questionnaire was administered in the ready room of each squadron. Additionally, researchers circulated between the two ready rooms during the administration of the questionnaire to answer any questions. The approximate time to complete the questionnaire was 15 minutes and all were returned. In order to eliminate any order effect, the eight scales of each questionnaire were randomly placed together. This was accomplished by generating random numbers to represent each of the respective scales; from these numbers the questionnaires were put together. Each questionnaire was assigned a subject number to allow for confidentiality. There was no apparent resistance to the questionnaire; in fact more than several participants were interested in the results of the study. The completed questionnaires (n = 78) were then entered into a database.

C. DATA TABULATION

Responses for the questionnaire were entered into a spreadsheet. The method utilized to record the data was specific to each scale of the questionnaire. A Quality Assurance process was conducted to ensure the data was entered accurately. Results of the process indicated a two-percent error in data entered. The method used to record the data for each scale was as follows:

(1) Background and Habits scale responses were recorded as follows: for the amount of alcohol consumption per week a 1 was recorded for a response of 1-3, a 2 for a response of 4-7, a 3 for a response of 8-12, and a 4 for a response of ≥ 13. For the comparison with their usual consumption a 5 point frequency scale was utilized to record the responses; 1 = much less than usual, 3 = normal or usual amount, and 5 = much more than usual. The second portion regarding nicotine usage was recorded as follows: a 1 was recorded for a response of < 1 dose per day, a 2 for a response of 1-10 doses per day, a 3 for a response of 11-20 doses per day, a 4 for a response of 21-30 doses per day, and a 5 for a response of ≥ 30 doses per day. The third portion regarding caffeine usage was recorded as follows: a 1 for a response of < 1 serving per day, a 2 for a response of 1-2 servings per day, a 3 for a response of 3-4 servings per day, a 4 for a response of 5-6 servings per day, and a 5 for a response of ≥ 7 servings per day.

(2) For the Motion Sickness during Flight Training scale, a ruler was utilized to record the value from the visual analog scale (0 – 100 mm) to estimate motion sickness for during flight and in general cases.

(3) Similarly, for the Drowsiness during Flight Training scale responses, a ruler was used to measure the value from the visual analog scale (0 – 100 mm) to estimate the value of sleepiness during flight and in general.

(4) Motion Sickness during Flight scale responses for each of the symptoms were recorded either as a 0, 1, 2, or 3 correspondingly.

(5) Fatigue scale responses were recorded as follows: for each statement both during flight and in general, either a 1 or 0 was recorded corresponding to each response of "Yes" or "No" respectively. Furthermore, each column's entries of 1's were summed to provide the total number of positive responses true during training and in general.

(6) Sleep scale responses were recorded using the technique described for the Fatigue scale.

(7) Motion Experience scale responses were recorded as follows: the number of experiences were recorded either as a 1, 2, 3, 4, or 5 corresponding to "none", 1-10, 10-20, 20-30, and >30. The frequency of vomiting, nausea, and drowsiness were recorded as either 1, 2, 3, 4, or 5 corresponding to a response of either "never", "rarely", "seldom", "frequently", or "always" respectively. Additionally, the number of flight hours flown in military and civilian aircraft was entered as integers.

(8) To determine an individual's Social Readjustment score, assigned value numbers for each affirmative scale response were summed to provide a total score. Holmes and Rahe (1967) state that an individual scoring less then 150 for his or her total score is identified as having only a 37% chance of becoming ill during the next two years.

Furthermore, a score of 150 to 300 raises the odds of illness to 51%, and a 300-plus score means an individual will have an 80% chance of becoming seriously ill (Coleman, 1976).

IV. RESULTS

The material of this chapter is presented in three parts. First, a breakdown of descriptive statistics is derived through non-parametric techniques associated with exploratory data analysis. Second, since the presence of Sopite Syndrome cannot be definitively shown, a symptomatic profile was drafted in order to conduct cluster analysis to divide individuals into low and high-risk groups. This is followed by a discussion of correlations between questionnaire items and group membership for Fatigue and Sleep scales.

A. EXPLORATORY NON-PARAMETRICS

In behavioral and social sciences, descriptive and non-parametric statistics play a prominent role for the researcher (Siegal & Castellan, 1988). In using non-parametric statistics, the given model specifies only extremely general conditions and none with respect to the specific form of the distribution from which the sample was drawn. Assumptions associated with non-parametric statistics are fewer and less restrictive or specific than those related to parametric tests; specifically, that the responses are independent and possibly that a variable being analyzed has underlying continuity. This analysis uses descriptive and non-parametric techniques on four scales delineated in the questionnaire: Motion Sickness during Flight Training, Drowsiness, Fatigue, and Sleep. The remaining scales are omitted.

1. Central Tendency and Dispersion

The mean, standard deviation, and inter-quartile ranges were calculated as measures of central tendency and dispersion for Motion Sickness during Flight Training, Drowsiness, Fatigue, and Sleep scales, on both "In General" and "During Flight" conditions (see Table 4.1). The data utilized for Motion Sickness during Flight Training and Drowsiness computations are continuous and taken directly off of visual analog scales. However, data for Fatigue and Sleep computations is discrete and was obtained by summing a subject's affirmative responses to nominal questions for each respective scale.

As shown in Table 4.1, the level or state of symptoms associated with Motion Sickness during Flight Training, Drowsiness, Fatigue, and Sleep increased in severity between "In General" and "During Flight" conditions. Motion sickness during SNFO training is relatively common: 60 out of 78 SNFOs (77%) developed an increase in level of motion sickness feelings. Figure 4.1 depicts the frequency of specific symptoms reported by SNFOs under the two separate conditions. Similarly, lowered arousal levels typically associated with drowsiness were experienced: 33 out of 78 SNFOs (42%) reported a decrease in arousal. Thirdly, factors symptomatic of fatigue (a primary symptom of Sopite Syndrome) were measured: 52 out of 78 SNFOs (67%) experienced an increase in symptoms between conditions. Finally, subjects recorded responses for sleep difficulties (a symptom related to Sopite Syndrome) for the two conditions stated above: 37 out of 78 SNFOs (47%) sustained increases in sleep difficulties.

Questionnaire Scales		Mean	Standard Deviation	1st Quartile	3rd Quartile
Motion Sickness	In General	4.40	8.78	1.00	3.00
	During Flight	32.81	32.66	4.25	65.00
Drowsiness	In General	17.05	16.18	3.25	25.75
	During Flight	20.62	24.16	1.25	26.75
Fatigue	In General	0.49	0.91	0.00	1.00
	During Flight	2.50	2.16	1.00	4.00
Sleep	In General	4.05	3.33	1.25	6.00
	During Flight	4.64	4.03	1.00	7.75

Table 4.1 Descriptive Statistics of Questionnaire Factors.

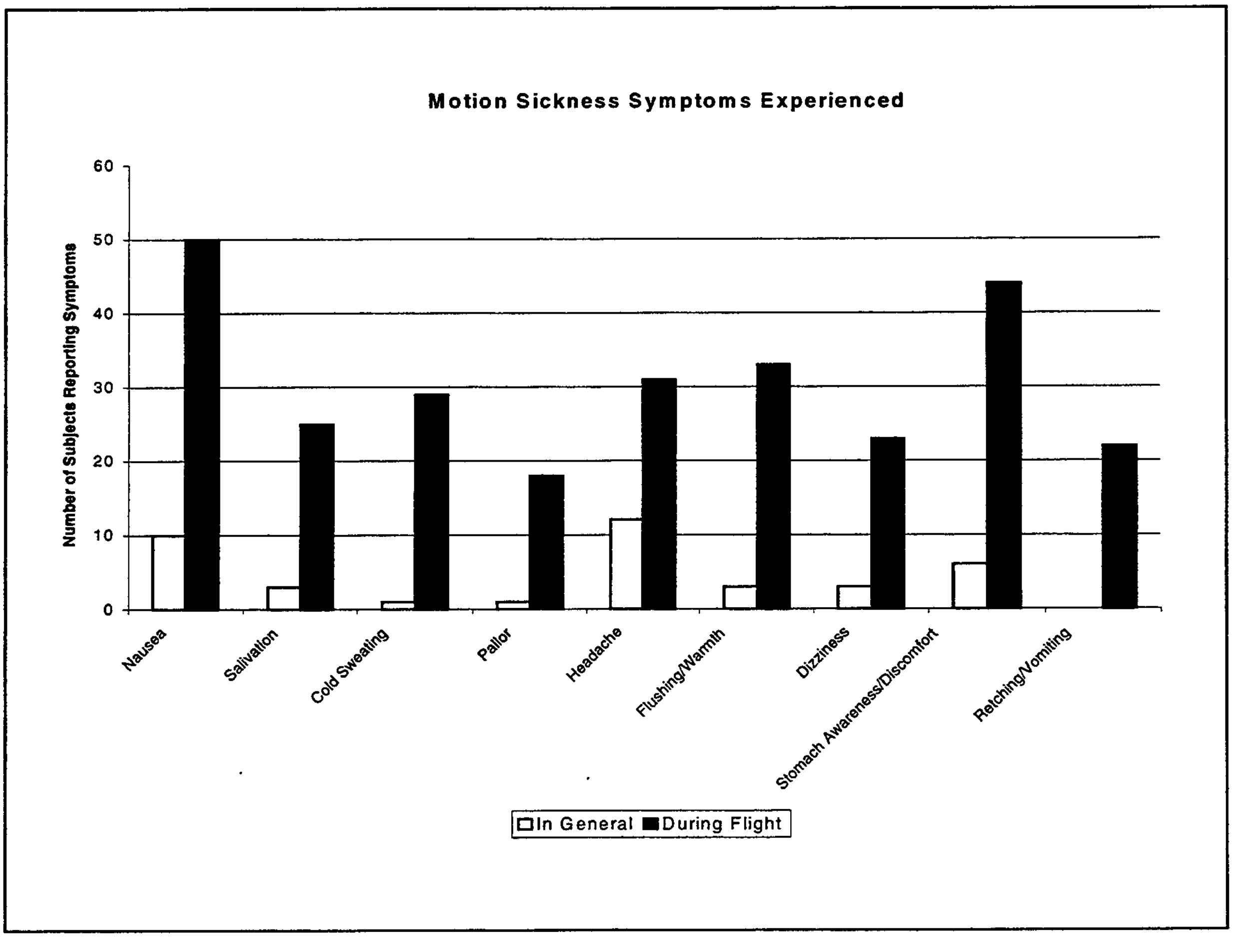

Figure 4.1 Motion Sickness Symptoms Experienced.

2. Significance Testing for Paired Data

The Wilcoxon Signed Rank Test is a very useful tool when working with behavioral data, and is applicable to the case of two related samples when attempting to determine whether two conditions are different (Siegal & Castellan, 1988). The two conditions being analyzed in the questionnaire are defined as "In General" and "During Flight". The test takes into consideration the direction and relative magnitude of the paired differences being tested. Table 4.2 summarizes the p-values for significance.

Questionnaire Scale	Wilcoxon Signed Ranks Test p-value
Motion Sickness during Flight Training	0.00
Drowsiness	0.52
Fatigue	0.00
Sleep	0.15

Table 4.2 Significance Values for Paired Data.

The size of increase was only significant in the case of Motion Sickness during Flight Training and Fatigue scales. The sets of data from the paired differences between "In General" and "During Flight" conditions for Motion Sickness during Flight Training, Drowsiness, Fatigue, and Sleep scales are illustrated through box plots in Figure 4.2. A box plot is a simple graphical representation exhibiting the center and spread of a distribution, along with a display of unusual data points deviating from normal behavior, called outliers (Hamilton, 1992).

The horizontal line located in the interior of a box plot is the median (Md) of the data. This estimates the center of the data. The height of the box is equal to the inter-quartile range (IQR), which is the difference between the first quartile (Q1) of the data and the third quartile (Q3). The first quartile (Q1) is a number greater than the values of

25% of the cases and lower than the values of the remaining 75%. Similarly, the third quartile (Q3) is a number greater than the values of 75% of the cases and lower than the remaining 25%. The inter-quartile range (IQR) measures the spread or width of the distribution of data. Dotted lines extend from each quartile to adjacent values, values that are the last cases not more than 1.5 * IQR beyond the quartiles (Hamilton, 1992). Furthermore, these characteristics of a box plot are resistant, or not easily influenced by a few extreme values.

As shown in Figure 4.2a, the horizontal line within the Motion Sickness during Flight Training box indicates the median (Md = 17), while the box length is determined by the first quartile (Q1 = 2) and the third quartile (Q3 = 58). Therefore, the inter-quartile range (IQR = 56) spans the middle 50% of the data and equals the height of the box. Farther-out values are called outliers and are graphed individually as horizontal lines. No outliers are evident in this box plot.

Figure 4.2b depicts the paired differences between the Drowsiness "In General" and "During Flight" conditions. The central box extends from the first quartile (Q1 = -7.75) to the third quartile (Q3 = 12), so its height equals the inter-quartile range (IQR = 19.75). The horizontal line within the box marks the median (Md = 0). The large number of high outliers and small number of low outliers reflect an overall positive skew of this distribution.

Figure 4.2c shows the paired difference value between Fatigue "In General" and "During Flight" conditions. The median value (Md = 2) is once again shown by the

horizontal line within the box. The first quartile (Q1 = 0) and the third quartile (Q3 = 3) are determined by the bottom and top edges of the box. The inter-quartile range (IQR = 3) is the distance between the first and third quartiles. The graph displays one high outlier, which is indicative of a very weary or exhausted individual.

Figure 4.2d is the distribution of the data from the paired differences between "In General" and "During Flight" conditions for Sleep. The graph shows that the data set is symmetric. The median (Md = 0) measures the center of the data, and the spread (IQR = 4) is determined by the first quartile (Q1 = -1) and the third quartile (Q3 = 3). This data set contains no exceptionally high or low values.

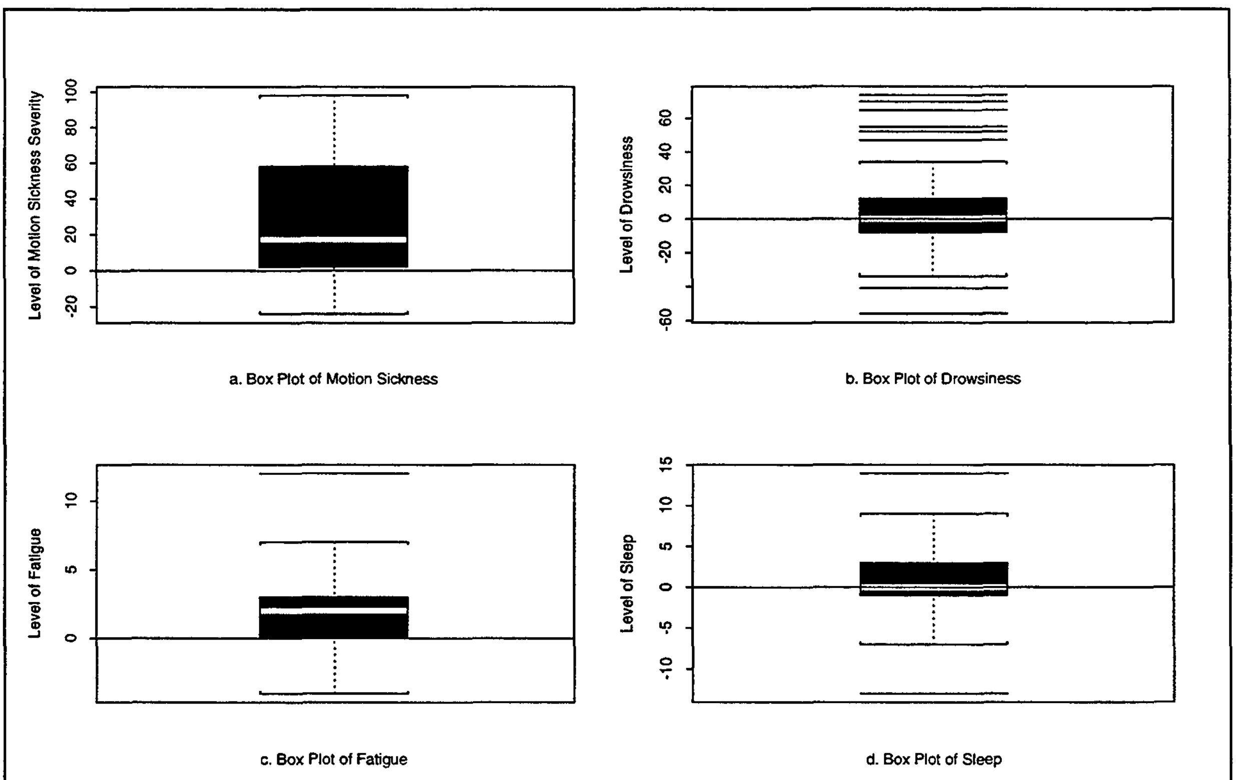

Figure 4.2 Box Plots of Paired Difference Values for Various Scales.

3. Correlational Analysis

The Spearman's rho, sometimes called the Spearman rank correlation, is a non-parametric statistic used to describe the relationship between the two sets of numerical data when the observations are skewed, possibly including outliers (Fink, 1995). To calculate Spearman's rho the data is put into rank order, from highest to lowest values to measure the association of the subjects under study. The magnitude of the various differences in individual subject scales gives us an idea of how close the relation between the two sets of ranks is. The values obtained through Spearman's rho can range from +1 to –1, with the positive and negative one being interpreted as perfect correlation between the ranks rather than the numerical values. Table 4.3 summarizes the results of the Spearman's rho calculations, and the simultaneous tests for zero correlation, for each respective pair of factors (alpha = 0.0083 (0.05/6) after applying the adjustment based upon the Bonferroni inequality).

Correlation	p-value	Spearman rho
Motion Sickness during Flight Training/Drowsiness	0.000	0.457
Motion Sickness during Flight Training/Fatigue	0.000	0.432
Motion Sickness during Flight Training/Sleep	0.006	0.312
Drowsiness/Fatigue	0.005	0.317
Drowsiness/Sleep	0.054	0.219
Fatigue/Sleep	0.002	0.361

Table 4.3 Measures of Association.

As shown in Table 4.3, Drowsiness/Sleep is the only pair of scales not significant under the null hypothesis that the correlation between each respective pair of factors is zero. Additionally, for those pairs that are significant, the Spearman's rho values range

from 0.31 to 0.46. For social science disciplines in human factors, correlations of 0.26 to 0.50 are considered quite high (Fink, 1995). Furthermore, an important finding is that an increase in motion sickness is correlated with increases in drowsiness, fatigue, and sleep.

B. SYMPTOMATIC PROFILE ANALYSIS

1. Symptomatic Profile Selection

Since the presence of Sopite Syndrome can not be definitively shown, a symptomatic profile was drafted per symptomology delineated in the literature. A key component in the diagnostic criteria of Sopite Syndrome is drowsiness. Hence, a decision was made to include only individuals who experienced an increase in severity of drowsiness between "In General" and "During Flight" conditions. Secondly, individual fatigue and sleep differences between conditions were considered part of the profile criteria. The study was interested in individuals who showed increases or no change in degree of symptoms between conditions. Hence, the symptomatic profile of a Sopite candidate is an increase in drowsiness between "In General" and "During Flight" conditions accompanied by an increase or no change in degree of symptoms with respect to fatigue and sleep. Twenty-five out of 78 SNFOs (32%) reported symptomology indicative of Sopite Syndrome.

A fundamental task while pursuing quantitative research in the social sciences is to formulate probability-based inferences about a population characteristic, using a sample drawn from that population (Fink, 1995). The problem with validity in the choice of Sopite Syndrome candidates can be attacked by the use of data permutation tests. A data permutation is a non-parametric technique for making such inferences. The

permutation differs from "bootstrapping" in that it employs large numbers of repetitive computations without replacement to estimate a population characteristic. No attempt is made to estimate the form of the sampling distribution. The technique utilized questionnaire data from the Motion Sickness during Flight Training scale. The decision for this choice was two-fold. First, this specific data was not used in the selection of the Sopite Syndrome candidates. Secondly, Sopite Syndrome candidates in past research have shown a higher level of motion sickness severity than the normal population.

Hence, the null hypothesis (H_o) is defined as: "Candidates" are just like the remainder of the sample population in their levels of motion sickness severity. Thus, if H_o is true, the sum of the 25 scores for the candidates should be comparable to the sum of any other random set of 25. Therefore, a function displayed in Appendix A to generate the sum of 25 random numbers from the original 78 data points for Motion Sickness during Flight Training was designed. Twenty-five numbers are used in the permutation, because 25 Sopite Syndrome candidates had been identified prior. The generated sums were then compared to the actual sum of the scores of the individuals identified as Sopite Syndrome candidates. A tally was kept as to the number of times the sum of the generated numbers exceeded the sum of the Sopite Syndrome candidates. The results were significant ($p < 0.05$); in zero out of 1000 trials exceeded the sum established by the 25 Sopite Syndrome candidates. Therefore, this test supports the profile criteria selection in identifying Sopite Syndrome candidates.

2. Central Tendency and Dispersion of Sopite/Non-Sopite Groups

Of the 78 eligible SNFOs, 25 (32%) were identified as meeting diagnostic criteria for selection as Sopite Syndrome candidates. The mean, standard deviation, and inter-quartile ranges were computed for differences between "In General" and "During Flight" conditions for Sopite and Non-Sopite group populations. Table 4.4 summarizes the values for the two groups. The extent to which the Sopite group exhibits the level or severity of symptoms is of a higher magnitude for each scale than that of the Non-Sopite group. Such results provide further evidence that the two groups differ.

Questionnaire Scales		Mean	Standard Deviation	1st Quartile	3rd Quartile
Motion Sickness	Sopite	41.76	30.49	15.75	73.75
	Non-Sopite	20.26	29.06	0.00	26.00
Drowsiness	Sopite	22.92	23.18	6.25	29.00
	Non-Sopite	-6.15	15.74	-11.00	0.00
Fatigue	Sopite	2.61	2.24	1.00	4.00
	Non-Sopite	1.67	2.41	0.00	3.00
Sleep	Sopite	2.46	2.19	1.00	3.75
	Non-Sopite	-0.33	4.33	-3.00	2.00

Table 4.4 Descriptive Statistics for Sopite/Non-Sopite Groups.

3. Significance Testing for Independent Data

When research involves variable measurement of ordinal quality or higher, the Wilcoxon-Mann-Whitney test may be used to test whether two independent groups have been drawn from the same population (Siegal & Castellan, 1988). Furthermore, Siegal and Castellan (1988) state that the test is considered to be one of the most powerful non-parametric tests, and is quite useful as an alternative to the parametric t test. The null hypothesis (H_o) of the Wilcoxon-Mann-Whitney test is that the two groups are from the same distribution. Hence, the alternative hypothesis (H_1) against which the null

hypothesis is tested is that Sopite candidates have scores that are stochastically higher than Non-Sopite population. The test was used to perform simultaneous tests, with respect to the various scales (four in all). If the null hypothesis is true, the p-value for the respective scales should be greater than an alpha level of 0.0125 (alpha =0.05/4, based upon the Bonferroni inequality). Therefore, if the resulting probabilities obtained is less than or equal to alpha, H_o will be rejected. Table 4.5 summarizes the p-values obtained from the Wilcoxon-Mann-Whitney test.

Questionnaire Scale	**Wilcoxon-Mann-Whitney Test p-value**
Motion Sickness during Flight Training	0.00
Drowsiness	0.00
Fatigue	0.07
Sleep	0.00

Table 4.5 Significance Values for Independent Data.

As shown in Table 4.5, the size of increase was significant for Motion Sickness during Flight Training, Drowsiness, and Sleep scales. Therefore, the probability associated with observing such an occurrence for each scale is very rare and quite extreme. Inasmuch as this probability is smaller than the previously set level of significance (alpha = 0.0125), the decision is to reject H_o in favor of H_1. It is concluded that the two groups are not from the same distribution.

4. Cluster Analysis

The goal of cluster analysis is to classify subjects into groups that are cohesive but distinct. It is a technique designed to perceive groups (clusters) in the data, in such a manner that subjects belonging to the same cluster look like one another, while objects in different clusters will look different. There exist a wide variety of clustering algorithms

which differ in the measures of cohesion and isolation, and weights assigned to these to determine the overall criterion to be optimized by the classification (S-PLUS 4, 1997). This study compared the actual symptomatic profile selection groups using two different hierarchical algorithms and one partitioning algorithm.

Johnson and Wichern (1988) state that hierarchical clustering techniques determine classifications by a series of either successive mergers or successive divisions. The two types are referred to as agglomerative and divisive hierarchical methods respectively. Agglomerative hierarchical methods begin with the individual subjects. Therefore, at the onset, there are as many clusters as there are subjects. Objects exhibiting the most similarity are the first to be merged. Additional mergers between individuals or groups then take place according to the extent of similarity. At the end, all the individuals will have been fused together into a single cluster. On the other hand, divisive hierarchical methods operate in the opposite direction by starting with one group and performing successive division. Partitioning algorithms allow the user to specify the number of groups "k" that the data set is to be divided into. Additionally, they usually provide a quality index, which allows the user to designate the best value of "k" after various computations are conducted on the data set (S-PLUS 4, 1997).

The three algorithms used in this thesis are described in S-PLUS 4 (1997). A description and example of the function will be given for each method. Additionally, a silhouette plot or clustering tree to compare group selection versus actual selection will illustrate the results for each method. Furthermore, Appendix B lists the subjects' (Sopite or Non-Sopite) classification for each of three methods described. There exist various

forms of each method tested; only the one that provided the best results will be shown and critiqued. Three option arguments are shared between the three functions. First, "`diss`" will be false in all three cases. This is due to the data-frame being a matrix of observations by variables. Secondly, "`metric`" specifies the means for calculating dissimilarities between objects. S–PLUS 4 (1997) currently allows the user to choose between two options, which are "`euclidean`" and "`manhattan.`" Euclidean computes its distances as root sum-of-squares of differences while manhattan distances are the sum of absolute differences. Thirdly, "`stand`" is true if measurements in the data-frame are standardized before calculating differences. The three methods are as follows:

(1) The function "`pam`" is a partitioning algorithm that does iterative relocation of group membership by minimizing the sum of dissimilarities of all objects to their nearest medoid (S-PLUS 4, 1997). A medoid refers to a representative object of a group that is computed by the algorithm. The user is allowed to select the desired number of groups "k", which when joined together determine a clustering. In this case, of course, "k" will be set to 2. S-PLUS 4 (1997) states the pam-algorithm is based on the search for "k" representative medoids among the subjects of the data set. After locating and identifying a set of "k" medoids, each subject is assigned to the nearest center in a manner that constructs "k" groups. So, the goal is to minimize the sum of the dissimilarities of the objects with respect to their closest center. The function call used is `pam(x, 2, diss = F, metric = "euclidean", stand = T).`

As shown in Figure 4.3, clustering data found by the function pam can be displayed in a silhouette plot (S-PLUS 4, 1997). For each subject a silhouette value is

calculated and portrayed on the plot as a bar of length equal to its value. S-PLUS 4 (1997) states that the silhouettes value can range from 1 to –1. A subject is considered well-classified for values close to 1, and the opposite holds true for a subject whose value is approximately –1. The entire plot displays the silhouettes of each subject, so the clusters' quality and contrast can be compared. The average silhouette width of the total data set for the function pam is 0.34. S-PLUS 4 (1997) states that average silhouette widths value greater than 0.25 identifies the existence of substantial clustering structure in the data set. In using the "pam" function, when each subject was assigned to a cluster there were 19 correct, 6 incorrect, and 9 misclassified choices in comparison to the actual Sopite Syndrome candidates identified. This is shown in Table 4.6, for an overall classification error rate of 19.2%.

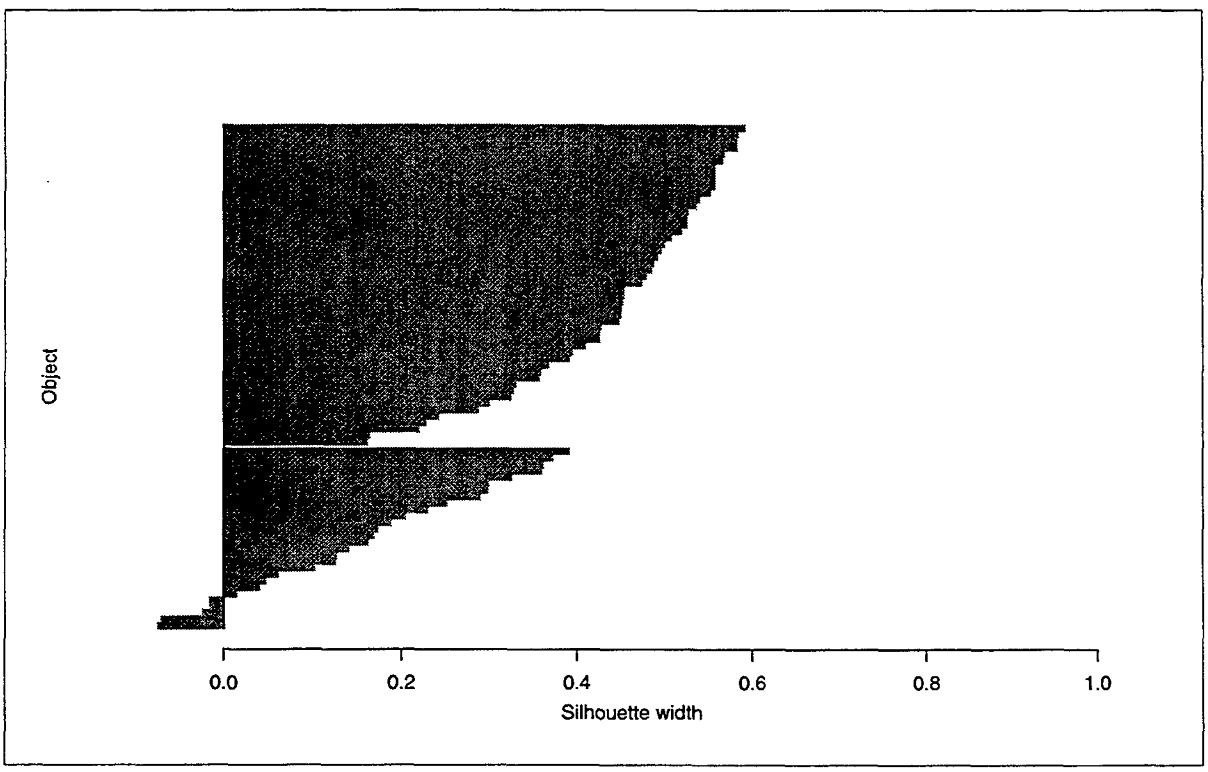

Figure 4.3 Silhouette Plot of Function "pam".

	"pam" function identified as Sopite candidate.	"pam" function identified as Non-Sopite candidate.
Identified as a candidate for Sopite Syndrome through chosen Symptomatic Profile.	19	9
Not identified as a candidate for Sopite Syndrome through chosen Symptomatic profile.	6	44

Table 4.6 Classification Analysis using "pam" Function.

(2) The function "agnes" is an agglomerative hierarchical method. Described in S-PLUS 4 (1997), the agnes algorithm builds a hierarchy of clustering. Initially, each object is treated as a small cluster in isolation. Eventually, clusters are merged until all the objects are contained in one large cluster. At each stage in the process, the two "nearest" clusters combine to form one cluster of larger size. Three different methods exist in computing cluster assignments: "average," "single," and "complete." "Average" proved to be the best choice of method with respect to the Sopite Syndrome data set. It computes the distance between the two clusters as the average of the dissimilarities between points in one cluster and points in the other. The function call used is

```
agnes(x, diss = F, metric = "manhattan", stand = F, method =
"average").
```

The resulting hierarchy acquired through the "agnes" function can be graphically displayed in a clustering tree, as depicted in Figure 4.4 (S-PLUS 4, 1997). The leaves of the tree represent the original objects in the data set, while the coordinate on the vertical axis where two branches join or intersect in the tree shows the amount of dissimilarity between the corresponding clusters (S-PLUS 4, 1997). This is equivalent to the distance between the respective clusters being merged together. In using the "agnes" function,

when each subject was assigned to a cluster there were 21 correct, 4 incorrect, and 14 misclassified choices in comparison to the actual Sopite Syndrome candidates identified. The two groups were determined by splitting the tree between the 44th and 8th leaves. The group to the right of the leaf numbered "8" inclusive is identified as Sopite Syndrome candidates. This is depicted in Table 4.8 and gives an overall classification error rate of 23.1%.

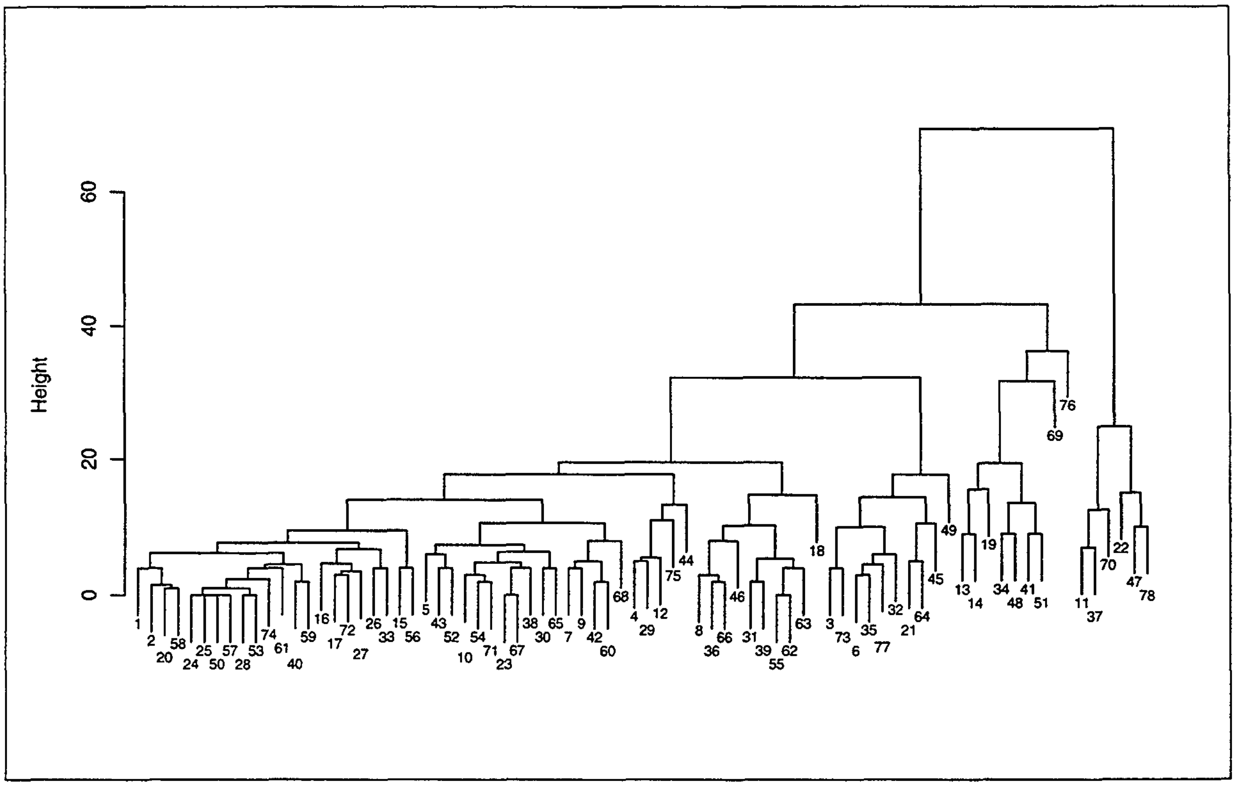

Figure 4.4 Cluster Tree of "agnes" Function (leaves on tree represent subjects).

	"agnes" function identified as Sopite candidate.	**"agnes" function identified as Non-Sopite candidate.**
Identified as a candidate for Sopite Syndrome through chosen Symptomatic Profile.	21	4
Not-identified as a candidate for Sopite Syndrome through chosen Symptomatic profile.	14	39

Table 4.7 Classification Analysis using "agnes" Function.

(3) The function "diana" is a divisive hierarchical method. Defined in S-PLUS 4 (1997) the diana algorithm begins with one large cluster containing all objects and builds a hierarchy of subsequent clusterings. The initial large cluster is divided repeatedly until each object is contained in a single cluster. At each stage in the process, the cluster with the largest dissimilarity between any two of its objects is selected for division. In doing so, SPLUS 4 (1997) first looks for the largest average dissimilarity to the other objects in the selected cluster. This particular object will act as the "splinter group". In the following steps, objects that are closer to the "splinter group" than to the original set are reassigned. The function called used is `diana(x, diss = F, metric = "euclidean", stand = F).`

Figure 4.5 displays the clustering tree for the function diana. In using the "`diana`" function, when each subject was assigned to a cluster there were 24 correct, 1 incorrect, and 16 misclassified choices in comparison to the actual Sopite Syndrome candidates identified. The two groups were determined by splitting the groups between the 75th and 8th leaves. The group to the right of the leaf numbered "8" inclusive is identified with Sopite Syndrome candidates. This is shown in Table 4.8, and gives an overall classification error rate of 21.8%.

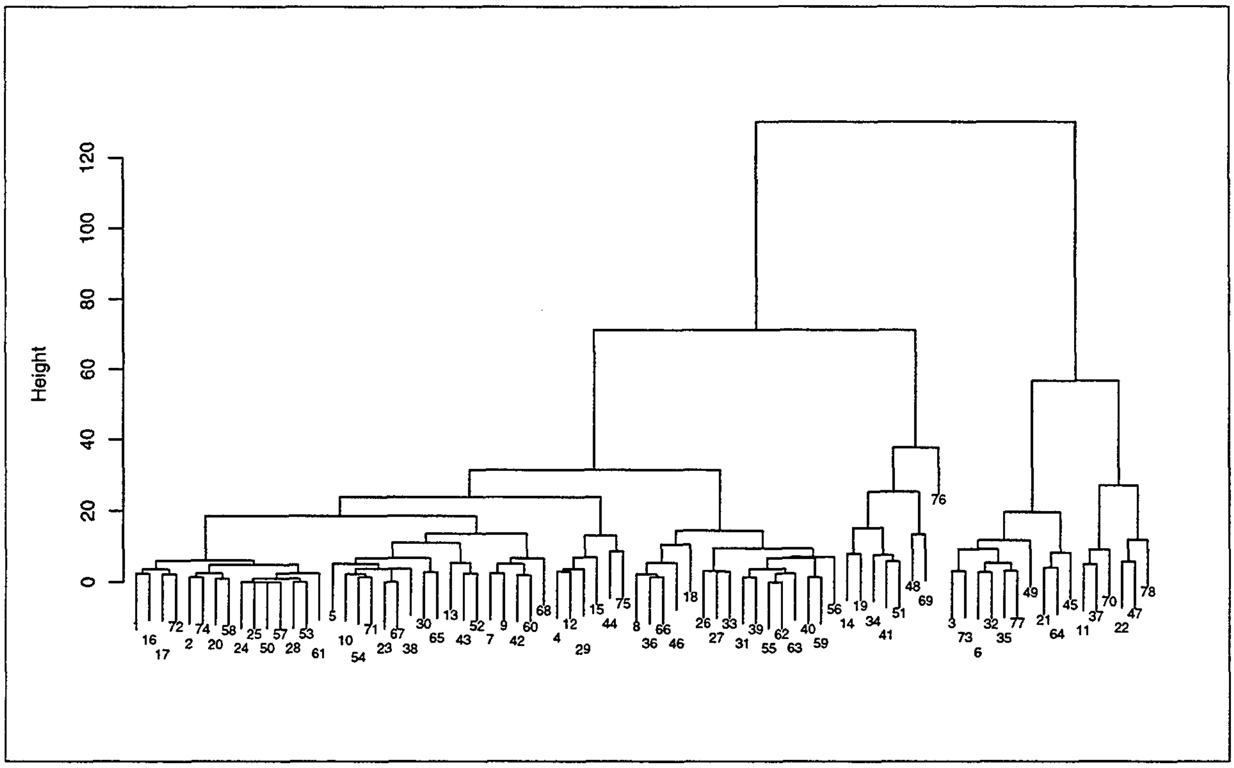

Figure 4.5 Cluster Tree for “diana” Function (leaves on tree represent subjects).

	“diana” function identified as Sopite candidate.	“diana” function identified as Non-Sopite candidate.
Identified as a candidate for Sopite Syndrome through chosen Symptomatic Profile.	24	1
Not-identified as a candidate for Sopite Syndrome through chosen Symptomatic profile.	16	37

Table 4.8 Classification Analysis using “diana” Function.

C. QUESTIONNAIRE ITEM ANALYSIS

In designing a questionnaire, it may be useful to simplify the analysis by considering a smaller number of questions. For example, there may exist questions that explain little to no variance in the selection of group memberships. Such questions provide hardly any information and may be removed altogether. Conversely, there may

be questions that explain variances of larger magnitude when analyzing group memberships.

One aspect of the squadron questionnaire was to request respondents to note which statements regarding the scales of Fatigue and Sleep were true during flight training. The respondents provided comment on various questions regarding the times when they felt their worst during a difficult training day. Therefore, having previously defined two groups of respondents (i.e. Sopite and Non-Sopite) a comparison of responses to individual questions was conducted for each group for the respective scales.

1. Fatigue Scale

The Fatigue scale consisted of 12 questions that are listed in Appendix C. At first glance, there exist a number of questions that may be nominees for removal. Using a non-significant response value of 10%, questions 4, 5, 6, 7 and 10 are nominated for removal. This results in a 42% reduction in the number of questions administered concerning the scale Fatigue. Review of the content for each question nominated identifies relationships of lesser magnitude to the primary symptoms of Sopite Syndrome then those remaining. Hence, this provides further justification in their removal. Additionally, questions 9 and 12 show a greater than 15% shift in response between groups. Each question is highly related to symptoms consistent with Sopite Syndrome. Hence, responses to such questions may be key indicators in determining individual group selection. Appendix D summarizes the response values for the two groups with respect to the Fatigue scale.

2. Sleep Scale

The Sleep scale was comprised of 38 questions that are listed in Appendix E. Defining a non-significant response difference to be at or below 10%, questions 2, 3, 7, 18, 20, 21, 22, 24, 26, 27, 29, 30, 31, 32, and 35 are nominated for removal. This reflects a reduction in 39% of the number of questions originally administered. To re-emphasize, the questions noted provided minimal insight into the selection of Sopite and Non-Sopite Syndrome candidates. On the other hand, questions 5, 9, 10, 11, 12, 14, 17, and 36 reflect noticeable variance between Sopite and Non-Sopite group selections using a 15% shift in response between groups. As stated earlier, such questions would be key indicators in the selection process. Appendix F summarizes the response values for the two groups with respect to the Sleep scale.

V. CONCLUSIONS/RECOMMENDATIONS

The purpose of this study was to determine if evidence of Sopite Syndrome existed in a sample population of SAs in operational flight training. This chapter provides conclusions concerning the results from the various analyses performed in this paper. Recommendations for further study are also provided.

A. EXPLORATORY NON-PARAMETRICS

The descriptive statistics computed here was successful in identifying significant changes and relationships between characteristics supporting the existence of Sopite Syndrome in operational flight training.

Through the use of Wilcoxon Signed Rank test, the size of increase between the "In General" and "During Flight" conditions for each respective characteristic was determined to be statistically significant in the case of the Motion Sickness during Flight Training and Fatigue scales ($p < 0.05$). In analyzing relationships, Spearman rho calculations were computed for respective pair of characteristics. Drowsiness/Sleep was the only pair of characteristics whose difference was not significant ($p > 0.0083$) under the null hypothesis that the correlation between each respective pair of characteristics is zero. An important finding from this research is that an increase in motion sickness was highly correlated with increase in drowsiness, fatigue, and sleep.

B. SYMPTOMATIC PROFILE ANALYSIS

Since the presence of Sopite Syndrome can not be definitively shown, a symptomatic profile was drafted per symptomology delineated in literature to determine

low- and high-risk group membership. The choice of candidates for Sopite Syndrome was validated using a permutation test. The permutation test differs from "bootstrapping" in that it applies large numbers of computations repeated without replacement to estimate a population characteristic. In summary, the permutation test showed that a significant difference existed between the Sopite Syndrome candidates and the remaining population ($p < 0.05$). Overall 25 of 78 (32%) of the SNFOs who participated in the questionnaire revealed symptomology consistent with the profile drafted.

A Wilcoxon-Mann-Whitney test of significance was conducted on the Sopite and Non-Sopite groups. Under the null hypothesis that the two groups are from the same distribution, the size of increase between Sopite and Non-Sopite candidates was significant for Motion Sickness during Flight Training, Drowsiness, and Sleep scales ($p < 0.05$). The null hypothesis was rejected and it is concluded that the two groups are not from the same distribution.

Finally, cluster analysis was used to classify subjects into low- and high-risk groups. The technique is designed to perceive groups (clusters) in data, in such a manner that subjects belonging to the same group look like one another, while subjects in different groups look different. The actual symptomatic profile selection groups were compared using the output from three different cluster analysis algorithms. The overall classification error rate for the various algorithms ranged from 19.2% to 23.1%.

C. QUESTIONNAIRE ITEM ANALYSIS

Fowler (1995) explains that a critical standard for a good question is that it produces answers that provide meaningful information about what is trying to be described. Additionally, the purpose of measurements is usually to produce comparable information about people or events. In analyzing the Fatigue and Sleep scale questions such objectives were taken into consideration.

Overall Fatigue and Sleep scale question design could have been shortened in length by 42% and 39% respectively by removing questions that provided little to no measurement of the objective, that being distinguishing between Sopite and Non-Sopite group memberships. These questions showed only weak relationships to the primary symptoms of Sopite Syndrome. Additionally, questions for each scale that may be key indicators for selection of individuals into group memberships were identified. These questions had a 15% or greater shift in response between Sopite and Non-Sopite groups. Each of these questions was considered highly related to literature research with respect to Sopite Syndrome symptomology.

D. CONCLUSIONS

This thesis provides a snapshot of Sopite Syndrome in operational flight training. The design of the squadron questionnaire was not intended to establish specific interpretations of symptomology, but to determine if Sopite Syndrome existed in a sample population of SAs in operational flight training. In fact, sufficient evidence was presented. Therefore, the techniques performed are deemed successful in supporting the existence of Sopite Syndrome in operational flight training.

E. AREAS OF FURTHER STUDY

The etiology of Sopite Syndrome remains elusive, but likely arises from a combination of physiological and psychological factors that vary in importance among susceptible individuals. The Navy has recently started the third phase into the existence of Sopite Syndrome at NAMRL. This additional testing includes the gathering of physiological data of participants subjected to the stimulus of the Human Disorientation Device (HDD). Analysis using classification trees, discriminant analysis, and logistic regression techniques to model Sopite Syndrome candidates may be performed on such data. With a more accurate database and the possibility of repeated measures, the information from this approach to investigating Sopite Syndrome provides additional opportunity for further research.

APPENDIX A. PERMUTATION FUNCTION

This Appendix provides an example of the function used to conduct a permutation test in this thesis. The example shows the code for each step taken and the respective arguments needed to execute the function.

```
function (n, v, sumsop)
{
# This Function is designed to generate the sum of 25 random numbers from the original
#78 data point 1000 times. Here "n" equals the desired number of repetitions, "v" is
# the original data set of 78 values, and "sumsop" equals the cumulative sum of motion
# sickness values for the 25 individuals identified as Sopite Syndrome candidates.
#
# The generated sum (i.e., sumsamperm) will be compared to the sum of individuals
# identified as Sopite Syndrome candidates.
#
# A tally will be kept as to the number of times the sum of the generated numbers
# (i.e., sumsamperm) exceeds the sum of the Sopite Syndrome candidates (i.e., sumop).
#
# A p-value of .05 is in effect.
#
#
        tally <- 0
        for (i in 1:n) {
                perm <- sample(v)
                sumsamperm <- sum(perm[1:25])
                if (sumsamperm > sumop)
                        tally <- tally + 1
        }
        return (tally)
}
```

APPENDIX B. COMPARISON OF SYMPTOMATIC PROFILE SELECTION GROUP MEMBERSHIP WITH OUTPUTS FROM VARIOUS CLUSTER ANALYSIS ALGORITHMS

Subject	Symptomatic Profile Selection	"pam" Method Selection	"agnes" Method Selection	"diana" Method Selection
1	Non-sopite	Non-sopite	Non-sopite	Non-sopite
2	Non-Sopite	Non-sopite	Non-sopite	Non-sopite
3	Non-sopite	Non-sopite	Sopite	Sopite
4	Non-sopite	Sopite	Non-sopite	Non-sopite
5	Non-sopite	Sopite	Non-sopite	Non-sopite
6	Sopite	Sopite	Sopite	Sopite
7	Non-sopite	Non-sopite	Non-sopite	Non-sopite
8	Sopite	Sopite	Sopite	Sopite
9	Non-sopite	Non-sopite	Non-sopite	Non-sopite
10	Non-sopite	Non-sopite	Non-sopite	Non-sopite
11	Sopite	Sopite	Sopite	Sopite
12	Non-sopite	Sopite	Non-sopite	Non-sopite
13	Non-sopite	Non-sopite	Non-sopite	Non-sopite
14	Non-sopite	Non-sopite	Non-sopite	Sopite
15	Non-sopite	Sopite	Non-sopite	Non-sopite
16	Non-sopite	Non-sopite	Non-sopite	Non-sopite
17	Non-sopite	Non-sopite	Non-sopite	Non-sopite
18	Non-sopite	Non-sopite	Sopite	Sopite
19	Non-sopite	Non-sopite	Sopite	Sopite
20	Non-sopite	Non-sopite	Non-sopite	Non-sopite
21	Sopite	Sopite	Sopite	Sopite
22	Sopite	Sopite	Sopite	Sopite
23	Non-sopite	Non-sopite	Non-sopite	Non-sopite
24	Non-sopite	Non-sopite	Non-sopite	Non-sopite
25	Non-sopite	Non-sopite	Non-sopite	Non-sopite
26	Non-sopite	Non-sopite	Non-sopite	Sopite
27	Non-sopite	Non-sopite	Non-sopite	Sopite
28	Non-sopite	Non-sopite	Non-sopite	Non-sopite
29	Non-sopite	Sopite	Non-sopite	Non-sopite
30	Non-sopite	Non-sopite	Non-sopite	Non-sopite
31	Sopite	Non-sopite	Sopite	Sopite
32	Sopite	Sopite	Sopite	Sopite
33	Non-sopite	Non-sopite	Non-sopite	Sopite
34	Non-sopite	Non-sopite	Sopite	Sopite
35	Sopite	Sopite	Sopite	Sopite

Subject	Symptomatic Profile Selection	"pam" Method Selection	"agnes" Method Selection	"diana" Method Selection
36	Sopite	Sopite	Sopite	Sopite
37	Sopite	Sopoite	Sopite	Sopite
38	Non-sopite	Non-sopite	Non-sopite	Non-sopite
39	Sopite	Non-sopite	Sopite	Sopite
40	Sopite	Non-sopite	Non-sopite	Sopite
41	Non-sopite	Non-sopite	Sopite	Sopite
42	Non-sopite	Non-sopite	Non-sopite	Non-sopite
43	Non-sopite	Non-sopite	Non-sopite	Non-sopite
44	Non-sopite	Sopite	Sopite	Non-sopite
45	Non-sopite	Sopite	Sopite	Sopite
46	Sopite	Sopite	Sopite	Sopite
47	Sopite	Sopite	Sopite	Sopite
48	Non-sopite	Non-sopite	Sopite	Sopite
49	Sopite	Sopite	Sopite	Sopite
50	Non-sopite	Non-sopite	Non-sopite	Non-sopite
51	Non-sopite	Non-sopite	Sopite	Sopite
52	Non-sopite	Non-sopite	Non-sopite	Non-sopite
53	Non-sopite	Non-sopite	Non-sopite	Non-sopite
54	Non-sopite	Non-sopite	Non-sopite	Non-sopite
55	Sopite	Sopite	Sopite	Sopite
56	Sopite	Sopite	Non-sopite	Sopite
57	Non-sopite	Non-sopite	Non-sopite	Non-sopite
58	Non-sopite	Non-sopite	Non-sopite	Non-sopite
59	Sopite	Non-sopite	Non-sopite	Sopite
60	Non-sopite	Non-sopite	Non-sopite	Non-sopite
61	Sopite	Non-sopite	Non-sopite	Non-sopite
62	Sopite	Sopite	Sopite	Sopite
63	Sopite	Non-sopite	Sopite	Sopite
64	Non-sopite	Sopite	Sopite	Sopite
65	Non-sopite	Non-sopite	Non-sopite	Non-sopite
66	Sopite	Sopite	Sopite	Sopite
67	Non-sopite	Non-sopite	Non-sopite	Non-sopite
68	Non-sopite	Non-sopite	Non-sopite	Non-sopite
69	Non-sopite	Non-sopite	Sopite	Sopite
70	Sopite	Sopite	Sopite	Sopite
71	Non-sopite	Non-sopite	Non-sopite	Non-sopite
72	Non-sopite	Non-sopite	Non-sopite	Non-sopite
73	Non-sopite	Non-sopite	Sopite	Sopite
74	Non-sopite	Non-sopite	Non-sopite	Non-sopite
75	Non-sopite	Sopite	Sopite	Non-sopite
76	Non-sopite	Non-sopite	Sopite	Sopite

Subject	Symptomatic Profile Selection	"pam" Method Selection	"agnes" Method Selection	"diana" Method Selection
77	Sopite	Sopite	Sopite	Sopite
78	Sopite	Sopite	Sopite	Sopite

APPENDIX C. FATIGUE SCALE QUESTIONS

Place an "X" next to each statement that was true for you during flight training. If the statement does not apply or is false, leave the space blank.

	TRUE DURING FLIGHT?
1. I tend to feel persistent, unexplained or recurrent fatigue that does not seem to depend on my level of rest or exertion.	_______
2. I tend to feel an impairment in my short term memory or concentration.	_______
3. I tend to feel a reduction from my previous levels of occupational, educational, social or personal activities.	_______
4. I tend to get sore throats.	_______
5. I tend to feel tender lymph nodes in my neck, armpits, or groin.	_______
6. I tend to feel muscle pain.	_______
7. I tend to feel multi-joint pain without joint swelling or redness.	_______
8. I tend to feel headaches of a new type, pattern or severity.	_______
9. I tend to have unrefreshing sleep.	_______
10. I tend to feel post exertional "malaise" (discomfort or uneasiness) lasting for more than 24 hours.	_______
11. I feel uneasy or uncomfortable during my first flight after a long lay off (more than week) from flying or between phases.	_______
12. I have felt sleepy after, even though I was well rested and received the usual amount of sleep prior to the flight.	_______

APPENDIX D. AFFIRMATIVE RESPONSE RATES FOR SYMPTOMATIC PROFILE SELECTION GROUPS CONCERNING INDIVIDUAL FATIGUE SCALE QUESTIONS

Question	Sopite Group	Non-Sopite Group
1	32%	19%
2	32%	23%
3	32%	28%
4	4%	4%
5	0%	2%
6	4%	6%
7	4%	9%
8	20%	11%
9	40%	21%
10	8%	4%
11	60%	57%
12	64%	43%

APPENDIX E. SLEEP SCALE QUESTIONS

Place an "X" next to each statement that was true for you during flight training. If the statement does not apply or is false, leave the space blank.

	TRUE DURING FLIGHT?
1. I have been told that I snore.	_______
2. I have been told that I hold my breath while I sleep.	_______
3. I have high blood pressure.	_______
4. My friends/family say I'm often grumpy and irritable.	_______
5. I wish I had more energy.	_______
6. I get morning headaches.	_______
7. I often wake up gasping for breath.	_______
8. I am overweight.	_______
9. I often feel sleepy & struggle to remain alert during the day.	_______
10. I frequently wake up with a dry mouth.	_______
11. I have difficulty falling asleep.	_______
12. Thoughts race through my mind & prevent me from sleeping.	_______
13. I anticipate a problem with sleep several times a week.	_______
14. I often wake up and have trouble going back to sleep.	_______
15. I worry about things and have trouble relaxing.	_______
16. I wake up earlier in the morning than I would like to.	_______
17. I lie awake for half an hour or more before I fall asleep.	_______
18. I often feel sad or depressed because I can't sleep.	_______
19. I have trouble concentrating at work or school.	_______

20. When angry or surprised, I feel my muscles going limp. _______

21. I have fallen asleep while driving. _______

22. I often feel like I am in a daze. _______

23. I have experienced vivid dreamlike scenes upon falling asleep or awakening. _______

24. I have fallen asleep in social settings such as movies/parties. _______

25. I have vivid dreams soon after falling asleep or during naps. _______

26. I have "sleep attacks" during the day where I fall asleep no matter how hard I try to stay awake. _______

27. I have episodes of feeling paralyzed during my sleep. _______

28. I wake up at night with an acid/sour taste in my mouth. _______

29. I wake up at night coughing or wheezing. _______

30. I have frequent sore throats. _______

31. I have heartburn at night. _______

32. During the night I suddenly wake up feeling like I am choking. _______

33. I have noticed (or others have commented) that parts of my body jerk during sleep. _______

34. I have been told that I kick and jerk during sleep. _______

35. When trying to go to sleep, I experience an aching or crawling sensation in my legs. _______

36. I experience leg pain or cramps at night. _______

37. Sometimes I can't keep my legs still at night, I just have to move them to feel comfortable. _______

38. Even though I slept during the night, I feel sleepy during the day. _______

APPENDIX F. AFFIRMATIVE RESPONSE RATES FOR SYMPTOMATIC PROFILE SELECTION GROUPS CONCERNING INDIVIDUAL SLEEP SCALE QUESTIONS

Question	Sopite Group	Non-Sopite Group
1	24%	25%
2	0%	2%
3	8%	2%
4	20%	8%
5	60%	32%
6	12%	4%
7	0%	0%
8	12%	11%
9	32%	11%
10	32%	9%
11	60%	23%
12	48%	32%
13	16%	9%
14	32%	6%
15	32%	26%
16	24%	13%
17	44%	23%
18	0%	6%
19	16%	13%
20	0%	2%
21	4%	2%
22	8%	6%
23	16%	11%
24	4%	2%
25	28%	19%
26	4%	2%
27	0%	4%
28	12%	2%
29	0%	2%
30	0%	2%
31	8%	4%
32	0%	0%
33	28%	17%
34	16%	8%
35	0%	2%
36	16%	0%

Question	Sopite Group	Non-Sopite Group
37	12%	8%
38	36%	25%

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